The Observing System Monitoring Center (OSMC)

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1. PROJECT SUMMARY

The Observing System Monitoring Center (OSMC) is an information gathering, decision support, and display system for the National Oceanic and Atmospheric Administration's (NOAA) Office of Climate Observations (OCO) located in Silver Spring, MD. The OSMC permits the many "networks" of *in situ* ocean observing platforms -- ships, floats, tide gauges, etc. -- to be viewed as a single system. It is a key integrating component for the management of a sustained Ocean Observing System for Climate.

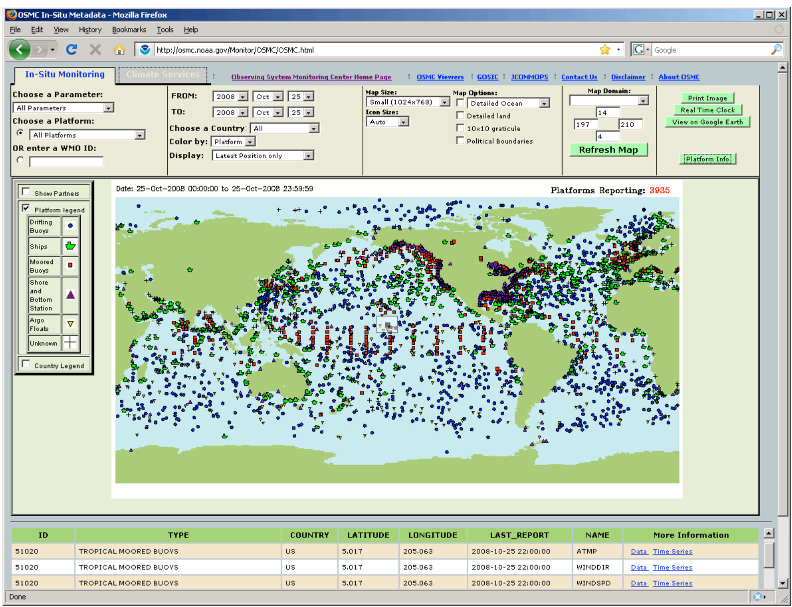


Figure 1. Screen snapshot of OSMC interface.

The OSMC system displays the current and historical status of the global observing system for *in situ* ocean surface meteorological and oceanographic measurements (Figures 1, 2). It provides dynamically generated maps to visualize the coverage of observations.

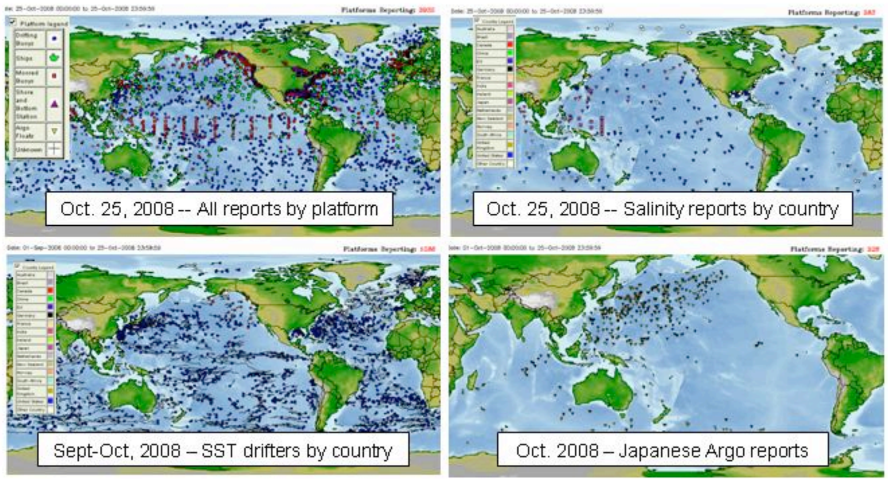


Figure 2. Sample OSMC maps.

The selection of observations may be constrained by observing platform, by parameter (temperature, sea level height, etc.), and by contributing nation. Maps may be requested for various time intervals – daily, weekly, monthly or arbitrary. With a click the user can "drill down" to see the metadata that describes a given observation.

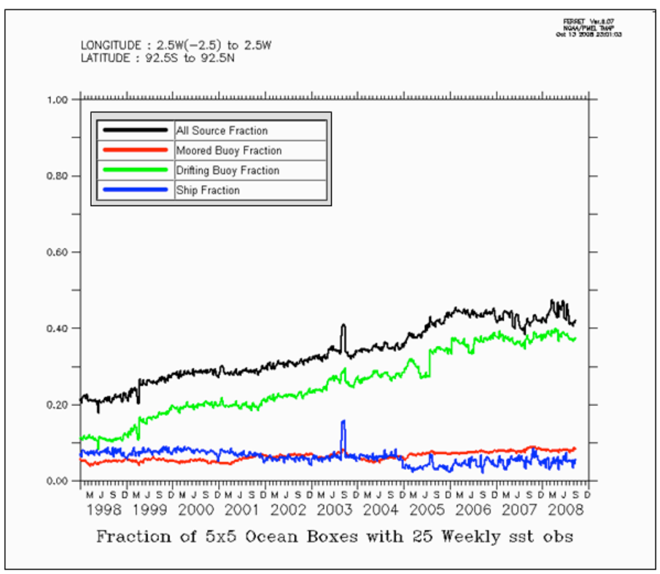


Figure 3. Progress in implementation of the ocean observing system.

Other viewers in the OSMC also provide time series showing trends in observing system coverage (Figure 3); they provide tabulated summaries, showing the counts, continually updated, of observations by ocean basin and platform type, and the contributing nation (Figure 4); and they provide visualizations of the observations on a globe with Google Earth® (Figure 7).

Number of Observing System Platforms Reporting

	Argo Floats	CMAN	Drifting Buoys	Moored Buoys	Ships	Unknown	Undefined	Sum
10-26-2008	121	349	1177	413	0	0	0	2060
10-25-2008	272	353	1179	414	524	49	330	3121
10-24-2008	297	358	1187	419	630	54	406	3351
10-23-2008	275	356	1191	414	606	54	392	3288
10-22-2008	266	357	1239	415	630	56	406	3369

*A count is defined as a platform reporting any type of observation on a particular day.

Figure 4. One of many OSMC table-based summaries.

The OSMC also offers analysis capabilities, developed through collaborative interaction with the Climate Observing System Council (COSC) and NOAA observing system scientists. These analysis capabilities help managers to assess the adequacy of the observations to compute critical ocean state fields, such as sea surface temperature. Figure 5 shows a 5x5 degree gridded analysis of a simple metric for the adequacy of the sampling of SST – the percentage of weeks in which at least 25 observations are made in a grid box during the 9 month period beginning Jan. 1, 2008.

The OSMC system is available on-line at http://www.osmc.noaa.gov. It is provided as a resource to other NOAA centers, national research partners, and international partners.

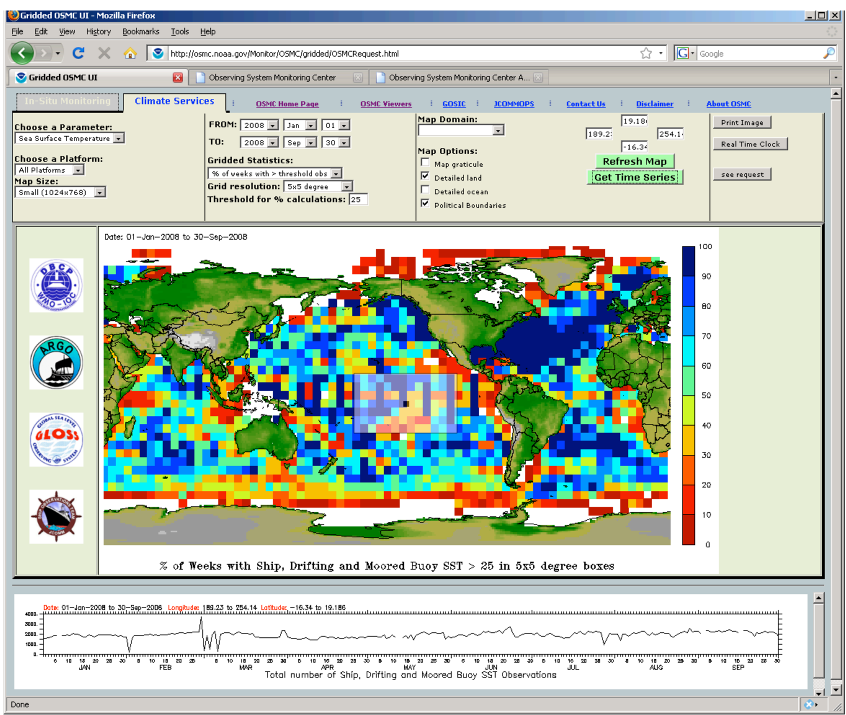


Figure 5. Analysis interface of the OSMC.

The OSMC project is a joint development effort between the Pacific Marine Environmental Laboratory (PMEL) in Seattle, Washington; the National Data Buoy Center (NDBC) at Stennis

Space Center in Mississippi; and the National Geophysical Data Center (NGDC) in Boulder, Colorado. The project is aligned to take advantage of the strengths of each organization. PMEL (an ocean/climate research laboratory) is responsible for the user interface/graphics/analysis tools; NDBC (an operational organization) is responsible for the data; and NGDC (a data center) provides technical consulting and development services on the use of data bases and standard services.

The OSMC is being designed in close cooperation with the JCOMM in situ Observing Platform Support Centre (JCOMMOPS). The development of the OSMC represents an important step towards the fulfillment of commitments to the Ten Climate Monitoring Principles.

2. PROGRESS

The following milestones track the progress made on OSMC during fiscal year 2008. "Group" lists only those accomplishments or events that involved the entire collaborative group.

2.1. Group Accomplishments (PMEL, NDBC, NGDC)

- The OSMC collaboration released the OSMC system through the publicly accessible OCO Web site. The OSMC site was advertised to the Climate Observing System Council (COSC), JCOMMOPS and OCO partners nationally and internationally.
- Outreach to the community regarding the value of the OSMC and the role of the community as participants in the OSMC occurred at multiple venues including:
    - "Monitoring and Analyzing the Global Ocean Observing System with the Observing System Monitoring Center", 88th Annual AMS meeting, Jan. 2008
    - "An Integrated View of the Ocean Observing system" presented at the 2nd Joint GOSUD/SAMOS Workshop, Seattle WA, June 10-12, 2008
    - "The OSMC-IOOS Collaboration Plan", at the IOOS Program Office Integrated Products Team Workshop, Silver Spring, July 7-8, 2008
    - "The Observing System Monitoring Center (OSMC) -- Steps Towards Climate Data Integration", at the Office of Climate Observations annual review, Silver Spring, September 3-5, 2008
- The OSMC development group and the operational OSMC continued to support OCO needs for materials and information needed for numerous initiatives, briefings, presentations, and ad-hoc requirements.
- An OSMC technical development meeting was held February 12-13 in Boulder to address database design issues associated with "duplicates" (multiple reports of the same observation internal to GTS and through delayed mode data sources).

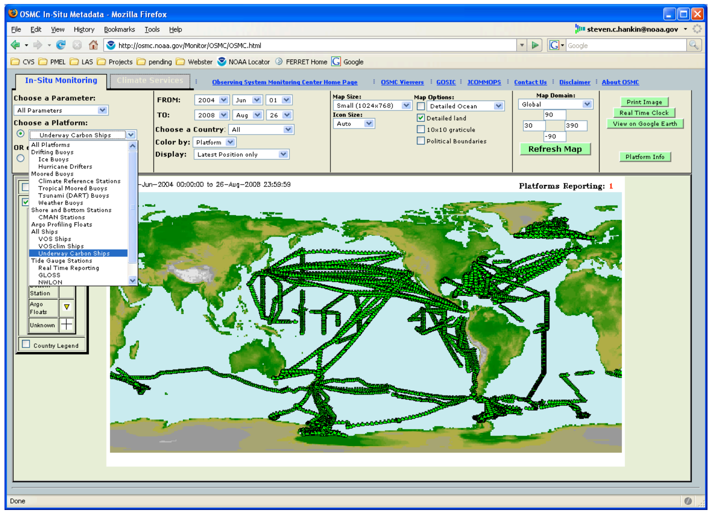


Figure 6. Carbon underway observations through the OSMC.

- The full OSMC group met for an OSMC all-hands meeting July 17-18, Seattle in which progress was assessed, strategic plans and priorities were decided upon, and technical issues that had been identified through weekly telcons were addressed. Among the many outcomes of this meeting were concrete plans for the incorporation of non-GTS data sources into the OSMC. The strategy to be followed will utilize the Climate System Markup Language (CSML) standard as an intermediate metadata representation for all non-GTS platforms.
- NDBC and PMEL worked together to arrange the first transfer of metadata from carbon observations into the OSMC database. Due to limitations in the quality and completeness of the metadata in the Takahashi collection the carbon observing system in the OSMC appears as a single monolithic (virtual) cruise as shown in Figure 6. The FY09 OSMC tasks describe the refinement of this initial step.
- Using graphical techniques prototyped by NGDC, the Google Earth® displays of OSMC metadata were improved as shown in Figure 7. The new style uses “placemarks” instead of an image. The platform icons on Google Earth® are clickable to retrieve metadata and data plots. We believe that Google Earth® can provide an excellent interface for those who wish to use the OSMC to monitor polar observations.

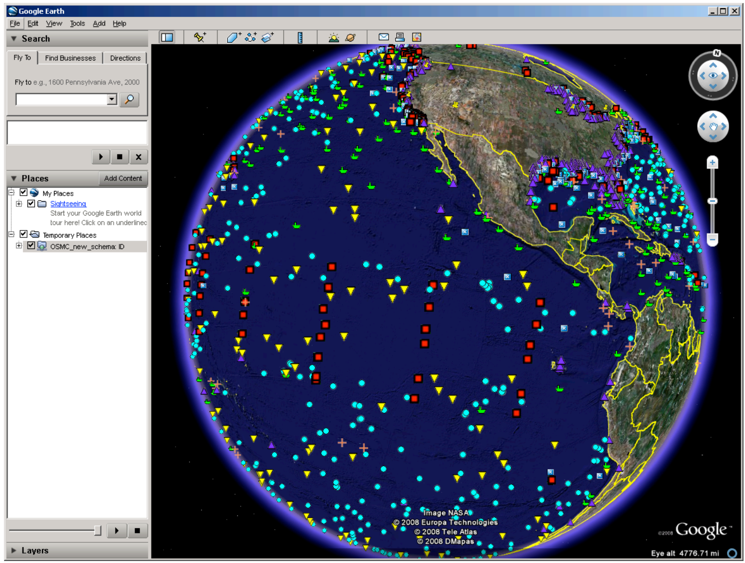


Figure 7. Google Earth® viewer showing ocean observations.

- Under the joint IOOS-OSMC tasks that were identified in May with joint funding from the IOOS Program Office NDBC and PMEL worked together to add IOOS as a new program type in the OSMC. This work has been partially completed. IOOS is the first program encountered in the OSMC that supports multiple platform types. Incorporating IOOS into the OSMC has revealed the need to generalize the concept of a "program" as modeled in the OSMC database.

2.2. PMEL ACCOMPLISHMENTS

- PMEL met its on-going project leadership responsibilities for the OSMC collaboration: organizing meetings and telcons; overseeing the tracking of bug fixes, milestones, and deliverables; coordinating plans of high level strategy; helping to ensure that group-wide communications continue to flow smoothly. PMEL also continued to provide the primary (though by no means sole) point for coordination of OSMC developments and outreach with projects such the Integrated Ocean Observing System (IOOS); the NOAA Data Management Committee (DMC); the NOAA "GEO-IDE" data integration framework; and NOAA science programs.
- In December 2007 OSMC version 3 was officially announced and made available from NDBC. It contains the following new features that PMEL developed or contributed to:
  - Through mouse-click "drill down" the OSMC interface provides plots of profiles, time series, and trajectories of ships and drifters. Figure 8 illustrates a TAO mooring time series.

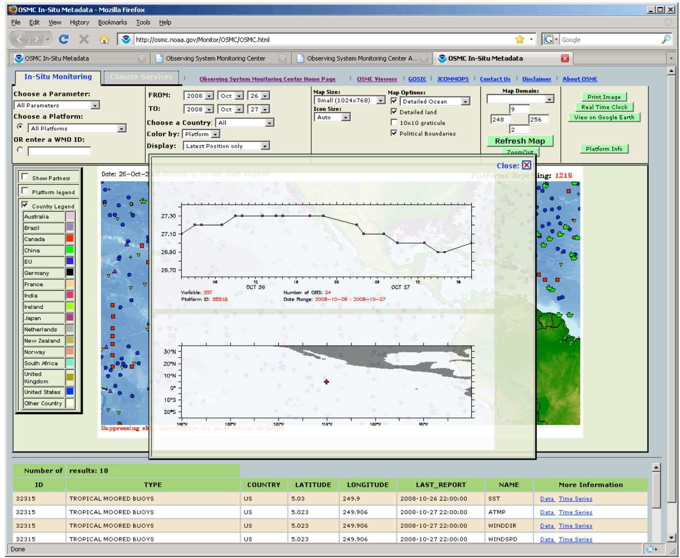


Figure 8. Data visualizations through "drill down".

- In Figure 9 we see Reynolds error bias fields as an underlay, providing perspectives on the adequacy of the *in situ* observing system.

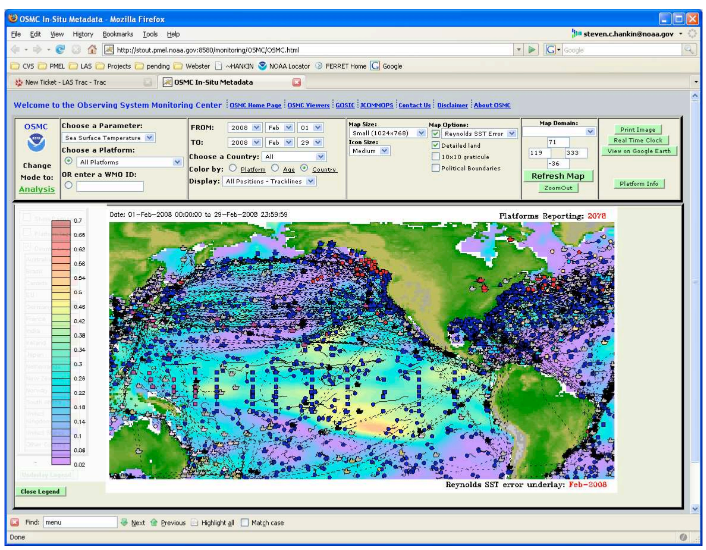


Figure 9. Observations overlaying Reynolds bias estimates.

- Improved the appearance and usability of the user interface through the use of a "tabbed" layout
- Improved click-and-drag selection, preserving aspect ratio
- The ability to color by parameter values as shown in Figure 10

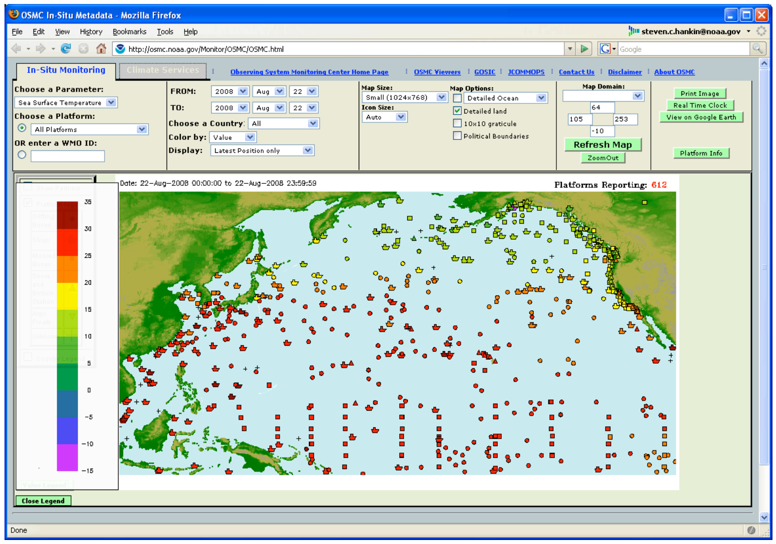


Figure 10. SST observations colored by value.

- Auto-sizing of icons was added based upon the density of information that is being displayed. The user can optionally over-ride this.
- OSMC color schemes were altered to more closely match those in use at JCOMM-OPS.

- A prototype viewer for collections of time series was developed as shown in Figure 11. This is a step towards the integration of U. Hawaii Seal Level and OceanSites time series. The prototype was efficiently developed using LAS for visualizations and the Google Web Toolkit® (GWT) for interface development. The code for this system was offered to U. Hawaii to speed along their system upgrades.

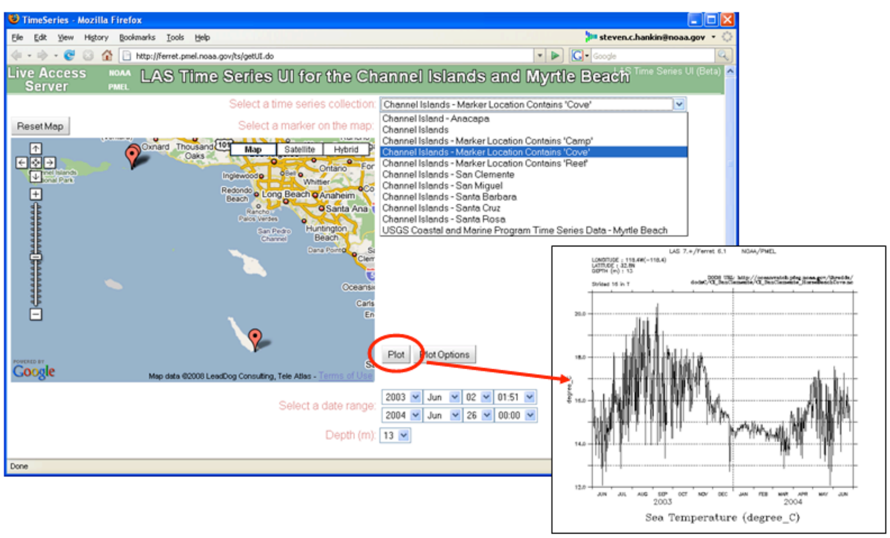


Figure 11. Prototype Web viewer for time series collections.

- A desktop Google Gadget® was created allowing OSMC users to customize their desktops with small OSMC viewers as shown in Figure 12.

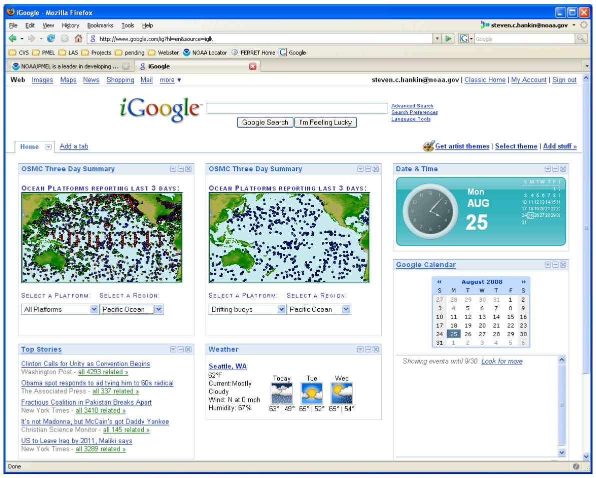


Figure 12. OSMC as a Google Gadget®.

- The following platform types and parameters were added or better differentiated in the LAS viewer
    - IOOS-managed platforms
    - VOSclim
    - Ice buoys
    - Tropical moored buoys
    - Weather buoys
    - Wave Height (new parameter)
    - Ocean CO_2

2.3. NDBC ACCOMPLISHMENTS

- Continued to update the OSMC Oracle database and NetCDF files with data from the following sources:
    - GODAE data files (Met and Profiles)
    - GTS feed from NWSTG (over 4,800 unique GTS headers)
    - WMO Allocation table (Country info)
    - WMO Pub 47 data (meta-data)
    - JCOMOPS WMO Platform Cross-Reference (meta-data)
    - NDBC Platform Data
    - VOS Clim Ships
- During fiscal year 2008 NDBC processed approximately 20 million observation records from the NDBC GTS feed and approximately 20 million more observation records from the GODAE feed. This represents a 17% increase in GODAE observations processed over 2007. (Note direct GTS processing at NDBC started in June 2007 so we could not calculate an annual increase from this feed.)
- During fiscal year 2008 added 3,240 new platforms to the OSMC database, an 11.8% increase.

- Data Enhancements:
    - Started ingesting XBT profile data
    - Ingested the Takahashi carbon data
    - Identified 154 ice buoys
    - Added wave height data
    - Added over 400 Realtime and NWLON Tide Gauges
    - Developed a CREX decoder for ingesting of tide elevation series data
    - Added additional headers (based on the GTS/GODAE comparison) to the GTS feed and started ingesting the data into the OSMC database.
    - Identified and resolved issues related to GODAE synthetic data (i.e. ZSAL).
- Database enhancements:
    - Working with NGDC and PMEL to identify Version 4 schema enhancements which includes the following:
        - Support for platform operational status information
        - Multiple URLs related to a platform
        - Storage of GTS header/type information
        - Storage of Quality Assurance data
        - Sensor/Instrument information
        - Add Program information, so that platform types are not used incorrectly.
        - Address duplicate resolution via an updated view
    - Developed routines to populate the Version 4 schema with a month of data to support the data/database analysis effort
    - Developed data migration scripts for the Version 4 schema
    - Inserted LOCATION parameter records for platforms not reporting parameter values
    - Identified duplicates and devised a set of rules for handling the duplicates along with detailed examples
    - Identified latitude and longitude precision differences between the GODAE (2 positions) and NDBC (3 positions) data feeds. This was impacting the C-MAN locations, which are fixed platforms.
    - Updated dew point difference to dew point temperature for impacted GODAE observations
    - Created new table space for indexes to improve database performance
- OSMC operational environment:
    - Performed OSMC server upgrades and security patches as required
    - Procured a replacement server and disk array to address performance issues.
- Integrated Ocean Observing System (IOOS) Support:
    - Identified IOOS platforms
- Miscellaneous Support:
    - Researched FNMOC QC flags
    - Researched the decoding and storing of GTS message header/type information to assist in future problem resolution.
    - Performed various analysis related to JCOMOPS/OSMC count differences
    - Implemented Webalizer web stats for the OSMC site
    - Coordinated with GODAE when unexpected data outages occurred

- Continued to research observations received on GODAE and not received via GTS. As of September 2008, there were 1,800 platforms that made 99,585 observations that reported on GODAE and not GTS from June 2007 to September 2008. Note: less than 65 of these platforms contained more than 100 observations for the period.
  - Assisted in the development of SQL queries in support of the user interface
- OSMC/DIF Accomplishments
  - Working to serve Sea Surface Temperature obs from OSMC via DIF developed SOS and will complete by 1st week of November 2008.
  - Enhanced contents of OSMC database to identify those observations which “belong” to IOOS.
  - Successfully registered the SOS with Compusult registry and working to ingest metadata into the OSMC database.
  - Provided NGDC with SOS database schema and provided several NDBC samples of the query code.
  - Developed a CREX decoder to ingest more observations into the OSMC database which will be served up into SOS.

2.4. NGDC Accomplishments

Task 1. Map Interfaces / Spatial Queries:
The application of COTS internet mapping tools to OSMC tailed off considerably during FY2008 as the project focused on maps provided by LAS and the NGDC team focused on database performance and design as well as access to OSMC using various standards.

Task 2. Database Performance and Design:
During the first half of the year we developed a number of queries for comparing the GODAE and direct GTS feeds and for identifying and counting observations from hierarchical platform types. These queries were examined using Oracle optimization tools and it was demonstrated that this analysis and subsequent changes to the queries led to significant improvements in database performance.

The OSMC Team as a whole spent a considerable amount of time developing and optimizing a variety of queries against various database designs during the year. The OSMC database design work addressed several major themes. The evolution of the database design is chronicled in the three Appendices 1-3. Appendix 1 shows the design at the beginning of the year (Version 3.0). This design is the basic parameter/value design that has been developed by NGDC throughout the OSMC Project. The main feature was the inclusion of separate observation value and parameter tables which allowed addition of new observation types or parameters to the database without altering the fundamental design.

Appendix 2 shows Version 3.5 of the database design, also referred to as the "location" design because the location was separated from the observation value. This design also included the capability to relate multiple URLs to platforms and to track time periods during which platforms were observing particular parameters.

This design was motivated by the requirement for identifying various kinds of duplicate observations. The systematic understanding and recognition of these duplicates was a major focus of the OSMC Team early in the year. Michelle provided an analysis which included examples of many types of duplicates. After much discussion by the entire team (see Appendix 4 Table) it was concluded that the Version 3.5 design could accommodate all of these duplicate types without additional, duplicate specific tables.

Version 3.5 was populated with several months of data at NDBC as a test to ensure that the queries required for OSMC could be run against the database. These results of these tests were positive. At the same time, new project requirement emerged which necessitated more additions to the design (see discussion of Version 4 below). It was agreed that further implementation work for Version 3.5 would be incorporated into the migration to Version 4 (see Appendix 3).

The next major step for the OSMC database design is reflected in Version 4, which includes sensors, programs, messages, and profiles for the first time. This design has been motivated significantly by detailed input from Derrick about the observing systems and the messages that are the primary source of information for OSMC and about requirements for monitoring details of the performance of the observing system using spatial tools. This design addresses a variety of new requirements:

1. GTS messages / bulletins information
2. Sensors in addition to platforms
3. Spatial queries for XBTs.

Climate Science Markup Language and Other Access Standards:

Our progress on Climate Science Markup Language was affected by delays in hiring a replacement for Nancy Auerbach, who moved to Australia. We now have hired David Neufeld as part of the OSMC project. David comes with extensive experience in geospatial data access and management. His initial focus has been on familiarizing himself with various CSML tools that are being developed by CSML experts at the Natural Environment Research Council and the Reading e-Science Centre in England in Python and Java. We have made progress with the Java version of the CSML tools and have succeeded in using those tools to read gridded data from netCDF files and to present those data as CSML. We have also developed a CSML service for tide gage time series data from the Alaska Tsunami Warning Center. These data are very similar to tide gage data included in OSMC, so that experience helps build our expertise for OSMC datasets. We are working with CO-OPS who will be using this service to ingest these data.

We have also made progress in using the open-source data access tool, Featureserver, with the OSMC database. This tool can be used to access data from a variety of data sources in different formats or in different databases. We have succeeded in accessing Oracle Spatial data sources and now need to customize that work to account for the OSMC Database Design.

IOOS-DIF Access to the OSMC:

NDBC has developed a Sensor Observation Service that is providing data in the IOOS/DIF format using a database design similar to the original OSMC database that existed when NGDC joined the project. We have started work to make it possible to serve those data using the OSMC Database as a data source. This can be done using a set of views that mimic the

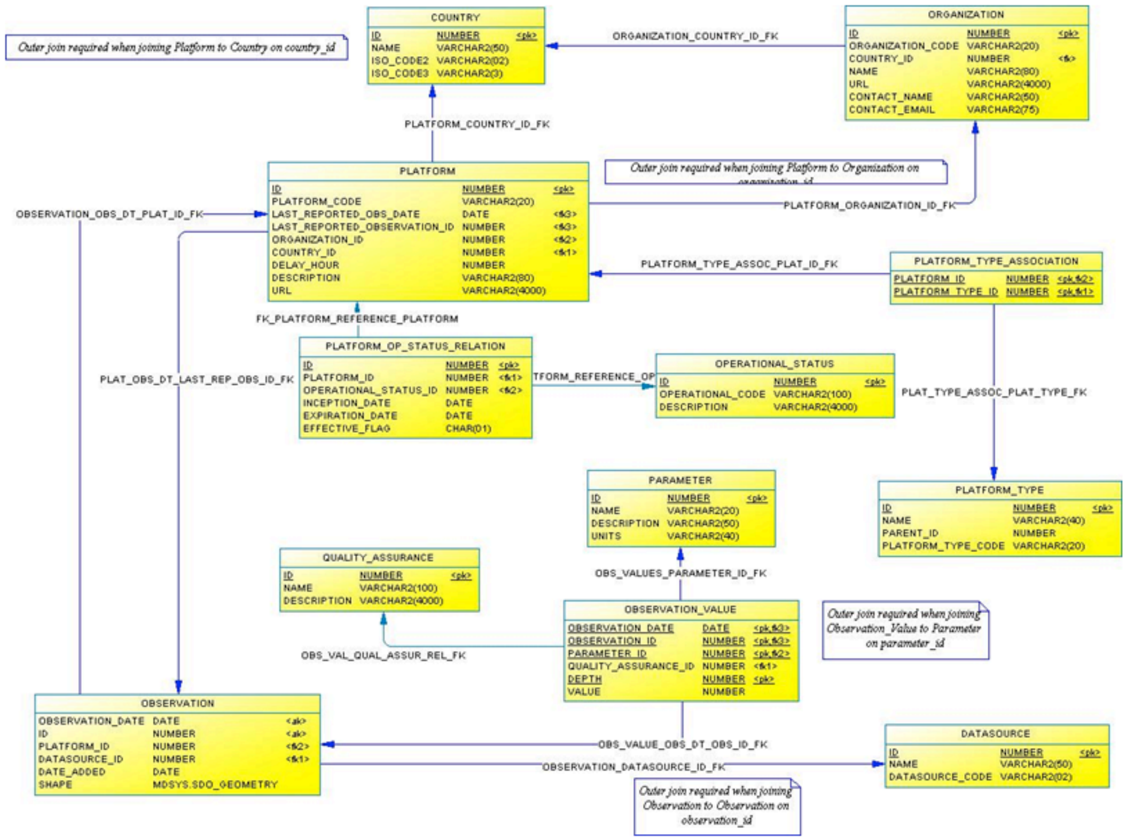
NDBC database design. We have received information from NDBC about their design and the four queries that they use to support the SOS: getCapabilities, describeSensor getObservation, and Bounding Box. We have proposed a view that supports the GetCapabilities request.

Other Tasks and Action Items:

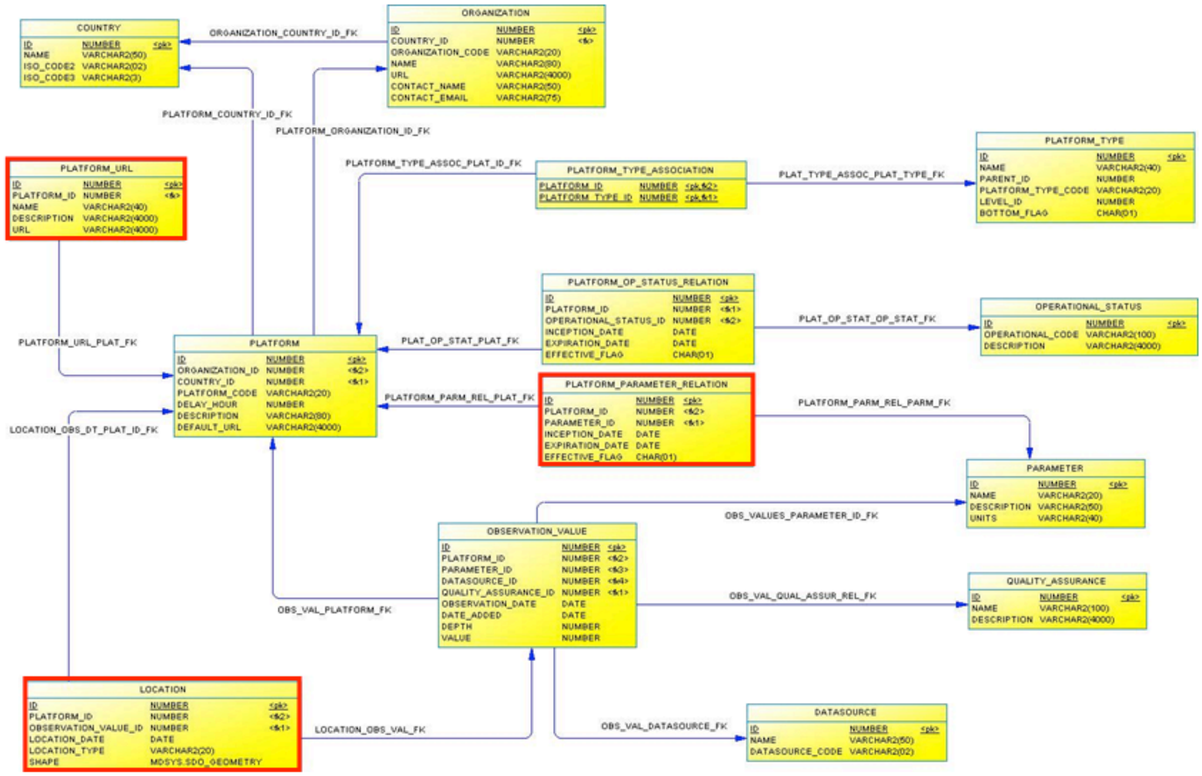
1. Developed Java programs to generate NetCDF observation count summary files using the new database schema. Counts are aggregated by platform type, parameter.
2. Refined the requirements for the XBT reporting facilities. Determined that database changes will be necessary to complete this task and incorporated those changes into Version 4 of the database design.
3. Developed views required to generate IOOS-DIF services for OSMC data.

3. APPENDIX

3.1. OSMC Version 3.0 design schematic

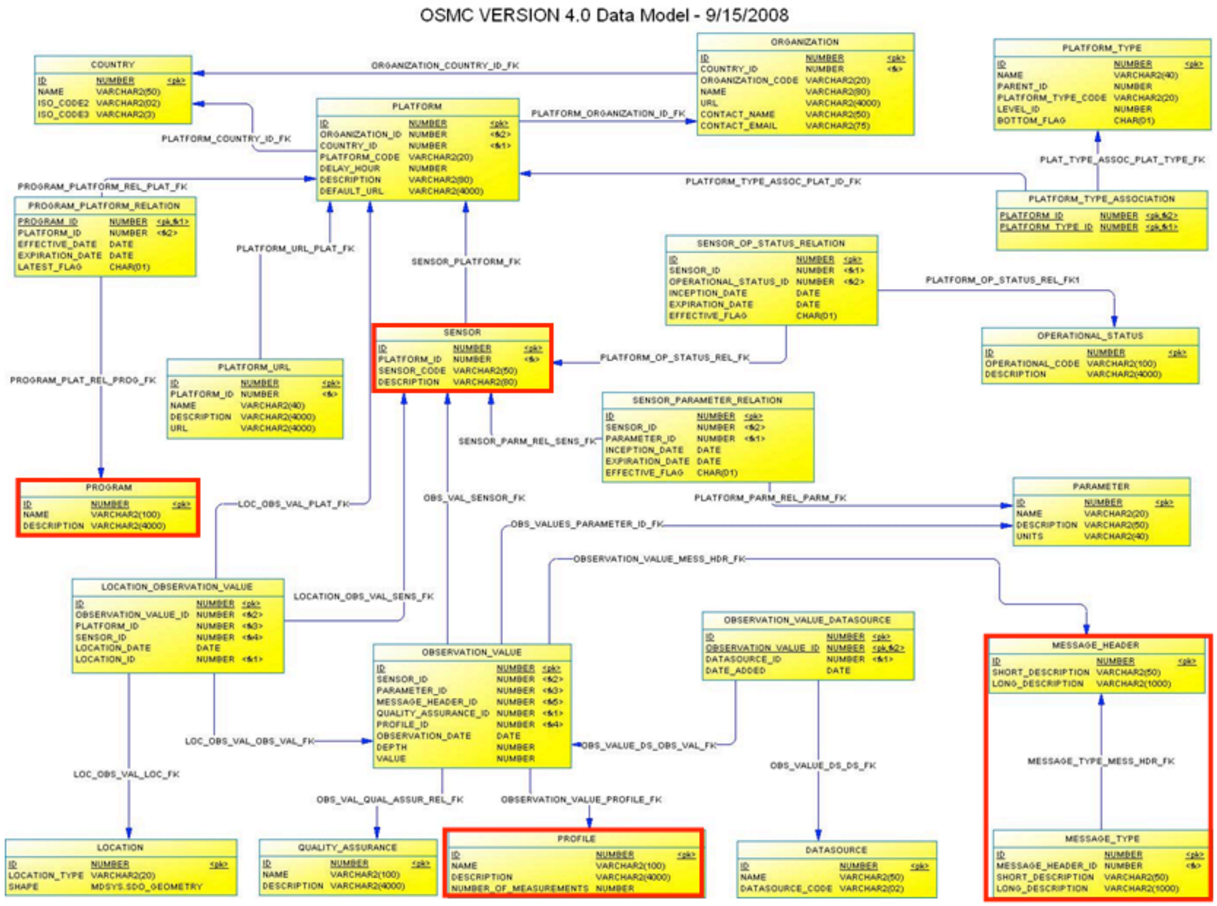


3.2. OSMC Version 3.5 design schematic



OSMC Database Version 3.5

3.3. SMC Version 4.0 design schematic



3.4. OSMC Design requirement for Version 4.0

Source	Description	Query Strategy
Steve's List from email "Re: OSMC - 'Duplicate' Observations" on 5/22/2008	REPORTS on the same OBSERVATION_EVENT may come from multiple SOURCEs	These are multiple rows in the OBSERVATION_VALUE table with equal PLATFORM_IDs, PARAMETER_IDs. OBSERVATION_DATEs, but different DATASOURCES
Steve's List from email "Re: OSMC - 'Duplicate' Observations" on 5/22/2008	REPORTS on the same OBSERVATION_EVENT may come at multiple delivery times (DATE_ADDED?) from the same SOURCE	This one is pretty similar to the last, but the DATE_ADDED is different and the DATASOURCE is the same
Steve's List from email "Re: OSMC - 'Duplicate' Observations" on 5/22/2008	REPORTS on the same OBSERVATION_EVENT may differ in the list of PARAMETERS they contain	Not sure I would call this a duplicate. It is more like an OBSERVATION_VALUE that gets added to a set of OBSERVATION_VALUES in an OBSERVATION.
Steve's List from email "Re: OSMC - 'Duplicate' Observations" on 5/22/2008	REPORTS on the same OBSERVATION_EVENT may differ in the VALUES of the PARAMETERS they contain	These are observations that do not agree: multiple OBSERVATION_VALUES for the same PARAMETER, PLATFORM, DATASOURCE (?).
Steve's List from email "Re: OSMC - 'Duplicate' Observations" on 5/22/2008	REPORTS on the same OBSERVATION_EVENT may differ in LAT/LONG (SHAPE) they contain	Multiple LOCATIONS with the same OBSERVATION_VALUE_ID
Michelle's Cases from the "Duplicate Report" of May 12, 2008	UNION	This case represents the same OBSERVATION_VALUES reported at two times. My inclination would be to reject the later OBSERVATION_VALUES in this case. If we keep them they could be found by the different DATE_ADDED values.
Michelle's Cases from the "Duplicate Report" of May 12, 2008	BEST_UNION	These are two OBSERVATION_VALUES from the same platform and time but for two different parameters at two different locations. The LOCATION_DATE and PLATFORM_ID fields in the LOCATION table allow us to describe this and to find how many occurrences we have of the same platform being at two locations at the same time.
Michelle's Cases from the "Duplicate Report" of May 12, 2008	CONFLICT_UNION	In this case we have two datasources reporting different parameters for the same platform and time, but at different locations.
Michelle's Cases from the "Duplicate Report" of May 12, 2008	BEST	Same OBSERVATION_VALUE from two datasources at different locations.
Michelle's Cases from the "Duplicate Report" of May 12, 2008	BEST	Same/different OBSERVATION_VALUEs from two datasources at different locations.
Michelle's Cases from the "Duplicate Report" of May 12, 2008	CONFLICT	Different LOCATIONS for different datasources.

3.5. Acronyms

ArcIMS	Arc Internet Map Server
DDL	Data Definition Language
ESRI	Environmental Systems Research Institute
FTE	Full Time Equivalent
FY	Fiscal Year
GEO-IDE	NOAA's Global Earth Observation Integrated Data Environment
GIS	Geographic Information Systems
GODAE	Global Ocean Data Assimilation Experiment
JCOMMOPS	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology Observing Platform Support
LAS	Live Access Server
NDBC	National Data Buoy Center
NGDC	National Geophysical Data Center
NOAA	National Oceanic and Atmospheric Administration
MS	Microsoft
OCO	Office of Climate Observations
OSMC	Observing Systems Monitoring Center
PMEL	Pacific Marine Environmental Laboratory
PP&I	Program, Planning & Integration
SDE	Spatial Database Engine
WMS	Web Map Service
WFS	Web Feature Service